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NATURE-BASED RESILIENCE AND ADAPTATION TO CLIMATE CHANGE IN HAWAIʻI

A Climate Ready Hawaiʻi Working Paper

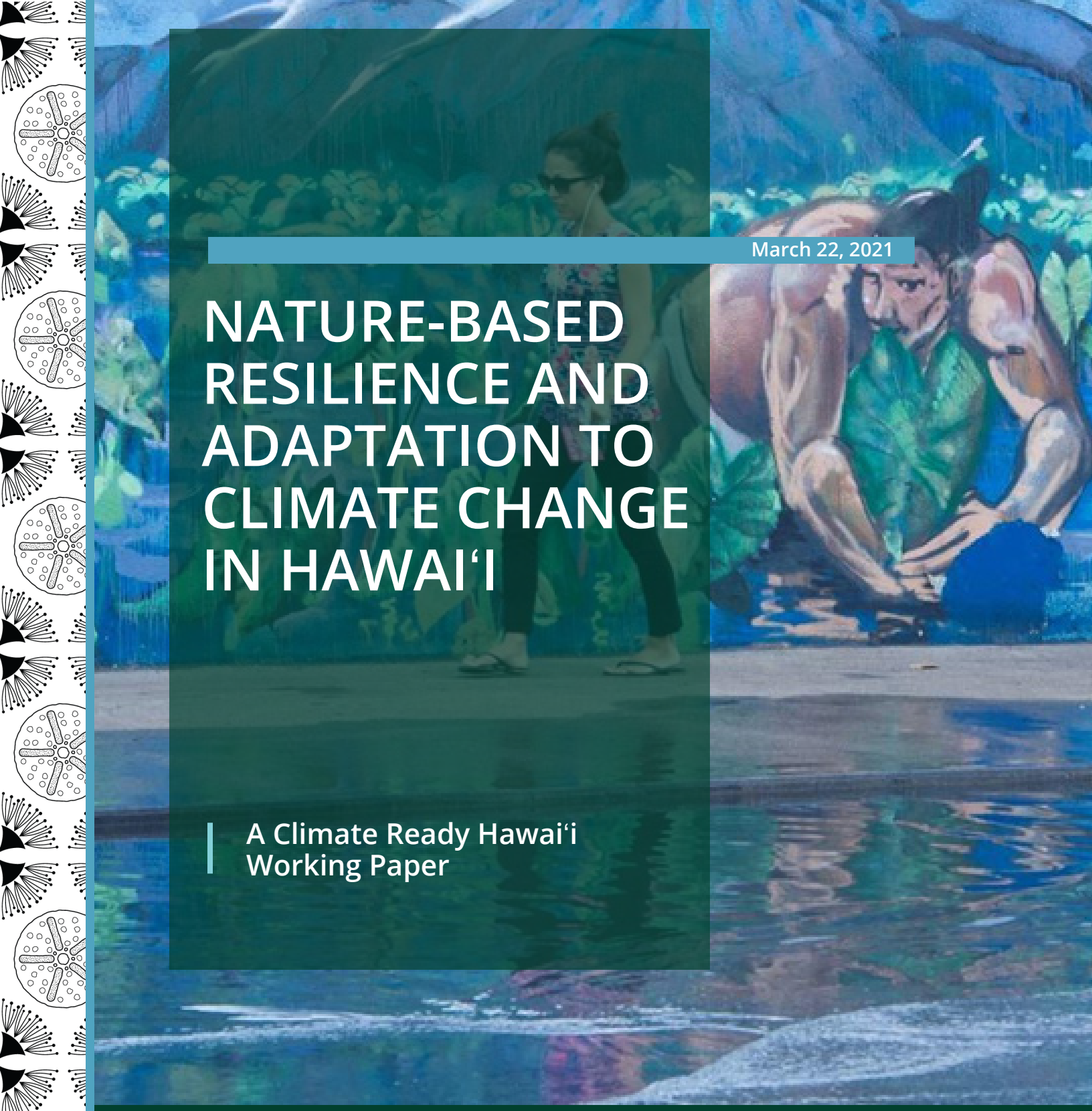

Photo: A pedestrian walks the flooded roads of Mapunapuna area, past a mural of a wetland taro farmer cultivating his field. “Sunny day flooding” will continue to worsen with rising sea levels due to climate change. The taro farm mural evokes the use of nature-based solutions to make Hawaiʻi climate ready. (Courtesy of Hawaiʻi Sea Grant King Tides Project)

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Disclaimer

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Contents

In a world that is falling short of meeting climate goals, Hawai‘i plays an important role in raising ambition. For Hawai‘i, as with its Pacific Island neighbors, climate change is an existential threat. Current international policies and pledges to reduce greenhouse gas emissions, if met, will result in an estimated 3-3.5°C of anthropogenic warming by 2100, a level of warming double that which is considered safe.[1] [2] While the U.S. rejoins the Paris Agreement and renews its pledges to keep global warming under 2°C, Hawai‘i must continue to lead by addressing its vulnerabilities and adaptation to climate change. The Hawai‘i Climate Change Mitigation and Adaptation Commission approved a Climate Ready Hawai‘i initiative to identify and address vulnerability to infrastructure in a manner that is "clean, equitable, and resilient."[3] [4]

Purpose and Scope

While Climate Ready Hawai‘i initially focused on sea level rise (SLR) impacts, it became clear that this document must tackle mauka-makai (coastal and landward) issues, and so, go beyond vulnerability to infrastructure to fully address climate change impacts in Hawai‘i.[5] This Working Paper highlights actions in Hawai‘i that rely on nature-based "green-blue" strategies to adapt to and mitigate climate change. It identifies ongoing efforts in the state, and key action areas for next steps that enhance climate readiness. We hope this document will be used by decision makers, planners, communities, businesses, and scientists as a guide for climate change resiliency work in Hawai‘i.

This document does not discuss the resiliency of the power grid, renewable energy resources, or sustainable transportation systems, although each of these have important roles to play in climate mitigation and goals of the state. Additionally, resiliency of the built environment is not considered in this document, even though green-blue infrastructure has a large role to play in climate readiness. Because of their complexity, we are unable to fully address climate equity and justice topics here. Since they are central elements of the Commission's mission, we address them in current and subsequent Climate Ready Hawai‘i Working Papers and companion documents. These Working Papers inform strategies for a Climate Ready Hawai‘i, and should be used and considered together.

Climate Ready documents can be found on the Hawai‘i Climate Portal on climate.hawaii.gov.

I. Climate Change: Threats, Risks, and Vulnerabilities in Hawai‘i

In Hawai‘i, climate change risks associated with increased temperatures, sea level rise (SLR), and changing rainfall patterns are resulting in extreme droughts and unprecedented flooding events. Saltwater contamination of low-lying agricultural lands and water sources due to SLR and increasing strength of storm surges will have negative effects on food production, water supply, and the state's economy. [6] SLR-related losses of land or freshwater supply for irrigation and drinking, and SLR-driven salinization will also negatively affect some traditional agro-ecological practices, such as loko i‘a (Hawaiian fishponds) and lo‘i kalo (wetland or flooded field taro systems), as well as some conventional agricultural practices, with impacts to food security and cultural practices in Hawai‘i.[7]

Figure 1. Known as the 'rainforests of the sea', our coral reefs provide vital ecosystem services for us, as well as allows for the diverse flora and fauna that thrive in these spaces. Land-based pollution and runoff eventually makes its way into our waters, putting our reefs' health at risk. Initiatives to protect our reefs and properly managing the adjacent lands will ensure the safety and health of our reefs and the services it provides. (Courtesy of He'eia National Estuarine Research Reserve)

Equity in Climate Action

Though climate change affects communities around the globe, the impacts and risks are felt differently by different communities. Climate change exacerbates existing

inequalities and can bring about new injustices in vulnerable and historically marginalized communities. To build climate equity, it is essential to center the voices and strengths of these communities, and acknowledge those institutions that have and currently do cause these disparities. Recognizing this, Hawai'i's Climate Commission puts equity at the center of its mission statement, to "promote ambitious climate-neutral culturally responsive strategies for climate change mitigation and adaptation in a manner that is clean, equitable and resilient."

Putting equity first in government planning

Many governments are shifting towards planning processes that put equity at the forefront. Hawai'i's Climate Commission urges all government entities in the state to:

- "Use a vulnerability framework that is appropriate for Hawai'i, and incorporate cultural responsiveness, reflect Indigenous voices and customary law practices to identify any inequitable distribution of benefits, burdens and processes caused by climate change impacts and policy; and

- Recognize and address the inequitable distribution of benefits, burdens and processes, by incorporating equity considerations from the beginning into their planning, policy development and implementation for climate change mitigation, adaptation and resilience."[8]

In California's Integrated Climate Adaptation and Resiliency Program's 2020 Impact Report, climate equity is highlighted: "The central equity challenges for climate change policy involve several core issues: addressing the impacts of climate change, which are felt unequally; identifying who is responsible for causing climate change and for actions to limit its effects; and understanding the ways in which climate policy intersects with other dimensions of human development, both globally and domestically."[9] Several other states have put forward equity reports and even, legislation. The European Union's new strategy on adaptation to climate change recognizes that "the local level is the bedrock of adaptation."[10] As we move forward in crafting strategies and policies

for adapting to climate change, and building resilience in Hawai‘i, there is an opportunity to enhance, rather than diminish, the capacity of those who are most vulnerable and least represented.

Vulnerable communities in Hawai‘i

Like Indigenous communities across the United States and the world, Native Hawaiians are disproportionately affected by climate change. Rising sea levels, declining freshwater availability, and changing ecosystems directly threaten communities' health and livelihoods, as well as their familial relationships with ancestral resources. SLR has impacted cultural practices such as loko i‘a maintenance, cultivation of salt, and gathering from nearshore fisheries. In Hawai‘i, effects of ocean acidification, drought, pollution and other climate change factors have already been documented.[11] [12] [13]

Identifying communities in Hawai‘i that are the most vulnerable to climate change impacts—Native Hawaiian, Pacific Islander, and other groups-- is central to correctly analyzing how strategies, policies and projects will affect them. The State of Hawai‘i is in the process of developing a vulnerability index to help describe such vulnerabilities. At the county level, the O‘ahu Office of Climate Change, Sustainability and Resiliency utilizes tools like the Centers for Disease Control's Social Vulnerability index,[14] and a combined map of social vulnerability and climate change.[15]

The State's role in providing an enabling policy and legislative framework is essential for local jurisdictions to adequately address equity issues of adaptation and resilience. To do so, we must understand existing vulnerabilities within communities and identify how they will interact with climate impacts so that benefits and burdens of climate change are equally distributed.

A more detailed discussion of equity in climate change mitigation, adaptation and resilience is being built out in companion Working Papers.

Identifying communities in Hawai‘i that are the most vulnerable to climate change impacts—Native Hawaiian, Pacific Islander, and other groups-- is central to correctly analyzing how strategies, policies and projects will affect them.

Climate change is a major threat to the state of Hawai‘i. The direct and indirect effects of climate change are already apparent, with numerous associated risks that need to be quantified and assessed for Hawai‘i to address its vulnerabilities to future change.[16] Here, we briefly summarize climate change threats, risks and vulnerabilities in Hawai‘i.

A. Rising Sea Levels

A combination of ice melt and land subsidence has translated into SLR of 10 inches on average since 1950 off the coasts of Hawai‘i.[17] [18] Current projections suggest that 3.2 feet of SLR or more may occur as early as 2060.[19]

Figure 2. Local sea level rise has impacts beyond the coastline. Here, we can see the increase of flood events in places like Mapunapuna in O'ahu. As sea levels continuing to rise, flooding is worsening further and further inland where seawater will flow backwards from storm drains – leading to pools of dirty, contaminated brackish water where we live, posing public health and economic risks for those that need access to these places. (Courtesy of Trista McKenzie, UH Mānoa)

Coastal erosion and inland flooding

Approximately 70% of beaches on Kaua‘i, O‘ahu, and Maui are eroding and progressively receding, which places increased pressure on exposed infrastructure from waves, in turn resulting in further land loss.[20] Through modeling via the Hawai‘i Sea Level Rise Viewer[21] tool it is clear that SLR will not only affect low-lying coastal communities, but inland flooding will also increase, impacting communities further from the coast.

According to the *Hawai‘i Sea Level Rise Vulnerability and Adaptation Report,* (2017), flooding caused by SLR of 3.2 feet will cost the state $19 billion. With this projection, “nearly 550

Hawaiian cultural sites would be flooded or eroded, 38 miles of major roads would be chronically flooded, and more than 6,500 structures and 25,800 acres of land located near the shoreline would be unusable or lost- resulting in approximately 20,000 displaced residents."[22]

B. Less but more intense rainfall

Hawai'i is getting drier. Rainfall has declined significantly over the past 30 years, with widely varying rainfall patterns on each island. This means some areas are flooding and others are too dry. Since 2008, overall, the islands have been drier. However, when it does finally rain, it rains heavily.[23] In March 2021, for example, Maui county issued a drought disaster for parts of Maui County and then experienced life threatening flooding that same week.[24] [25]

Figure 3. Heavy rainfall events and the resulting landslides and flooding have devastated areas throughout Hawai'i, causing damages to homes, buisinesses, and trasportation infrastructure. In March 2021, the islands of Maui, Kaua'I (shown here), and O'ahu experienced flashflood events that prompted the governor to declare a State of Emergency. As weather and rainfall patterns continue to shift, extreme weather events like these are likely to occur more often. (Courtesy of HIDOT)

Intense rainfall means runoff, erosion, flooding, and landslides

Extreme rainfall events not only tend to disrupt human activity, but can be catastrophic to life and property. In 2018, Kaua'i's north shore experienced the single-biggest rain event in U.S history.[26] This event caused an estimated $20 million in damage to public property, affected more than 500 homes, and cut off access to Wainiha and Hā'ena for more than two weeks.[27] In 2015, El Niño brought 11 days of record-setting rainfall to Honolulu.[28] The resulting flash floods, impassable roads, landslides and shuttered businesses provide an eerie glimpse into the future of what climate change will bring to the islands. In urbanized areas such as Waikīkī, which was once a wetland and is now

the most populated area in Hawai‘i, drainage failure and flooding pose a risk to a significant portion of the population. Even as this paper is being written, torrential rains and ensuing floods affecting the islands have led the Governor to declare a state of emergency.[29]

Rainfall variability and water shortages

Water shortages have been identified as one of the most critical climate-related risks to island nations.[30] Dry areas are projected to get drier, which will likely result in regional water shortages. Intense rainfall events, such as those described above, are also not ideal for aquifer recharge. Aquifer depletion results in negative effects on groundwater dependent ecosystems including anchialine pools, lo‘i kalo, loko i‘a, and nearshore ecosystems.

Figure 4. Each year Hawai‘i loses the same percentage of land to wildfire as California. These wildfires are the result of drought conditions caused by climate change and present a critical threat to the state. In 2018-2019, Maui saw a 500% increase in acres burned by wildfire, with a single wildfire burning over 10,000 acres and forcing thousands of residents to evacuate their homes. (Courtesy of DLNR-DOFAW)

C. Rising Temperatures

Hawai‘i, along with the rest of the world, has seen an increase in temperatures. Temperatures are increasing at four times the rate of half a century ago.[31] The last five years have seen peak average annual temperatures across all islands, and 2019 was the hottest year ever recorded on O‘ahu, featuring the hottest day ever recorded in Honolulu’s history.

Heat waves pose a severe threat to public health

The U.S. Environmental Protection Agency estimates that 1,300 deaths per year in the United States are attributed to extreme heat.[32] Research demonstrates a consensus that rising temperatures will lead to an increase in heat-related deaths and illnesses.[33] This is particularly relevant for Hawai'i given the increasing rate of warming air temperature, which has quadrupled in the last 40 years to over 0.3°F (0.17°C) per decade.[34] [35] Pre-existing health conditions such as obesity, which affects nearly 22% of adults in the state, are of increasing concern for the local population in the face of climate change.[36]

A hotter, drier Hawai'i means more wildfires and more erosion

A hotter, drier Hawai'i means an increased presence and risk of wildfire. More relative area burns per year in Hawai'i than any other state, and rising temperatures will exacerbate this trend. The extent of area burned annually in Hawai'i has increased four-fold in recent decades, rivaling the western U.S. in terms of the percentage of land area affected annually. [37] Wildfires allow invasive species such as strawberry guava, to outcompete native species such as 'ōhi'a lehua, and lead to increased runoff and erosion.

Rising temperatures and more CO2 affect Hawai'i's oceans

Increased ocean temperatures bring increased mortality and disease to native species of aquatic life. In 2015, due to increased ocean temperatures, Hawai'i experienced a bleaching event that resulted in an average mortality of 50% of the coral cover in western Hawai'i.[38] These coral reef bleaching and mortality occurrences have increased, and projections show that these events may occur annually by 2050, putting our reefs at high risk.[39]

> **How a community is affected by climate change is influenced by the vulnerability and sensitivity of that community to a hazard event, as well as the ability for that community to prepare, respond, and recover from a hazard event.**

Other climate impacts, such as ocean acidification- caused by increased carbon dioxide absorbed by the ocean, is causing corals and other calcifying species to erode away. Increasing levels of land-based runoff exacerbate these impacts and make it

harder for reefs to recover and be resilient to the effects of bleaching.[40] Warming waters are also projected to reduce the mixing of nutrients into the surface zone, resulting in a reduction in tuna and billfish species abundance in the central Pacific Ocean and a decline in maximum fisheries yields by 2%-5% per decade.[41] [42]

Unpredictable and changing weather patterns affect vulnerable people disproportionately

Increased frequency and intensity of extreme weather events, as well as risks posed by new or unexpected threats that emerge from changes in the surrounding environment will negatively affect all aspects of life in Hawai‘i. How a community is affected by climate change is influenced by the vulnerability and sensitivity of that community to a hazard event, as well as the ability for that community to prepare, respond, and recover from a hazard event. Factors such as age, race, health, income, and community cohesion often greatly influence the magnitude of impacts, as well as the duration or longevity of their effects.[43] [44] [45] For this reason, climate change affects vulnerable communities more. [46] However, work needs to be done on defining and describing vulnerable communities in Hawai‘i to adequately address risks from climate impacts.

II. Ahupua‘a-Moku Approach to Climate Readiness

To help build resiliency, a Climate Ready Hawai‘i looks to the traditional Hawaiian land divisions –the ahupua‘a and moku--that connect mauka and makai resources.47 The state Office of Planning- Coastal Zone Management Program’s most recent Ocean Resources Management Plan acknowledges that “most – if not all – natural resource agencies recognize that activities that take place mauka, flow makai, where they impact streams, springs, aquatic ecosystems, nearshore waters and the ocean.”48 Because Pacific islands are characterized by relatively small watersheds and tightly linked land-sea resources, terrestrial agricultural practices and marine ecosystem health are intricately linked.49 It follows, then, that natural and working lands (NWL), coral reefs, fisheries, coastal agriculture, aquaculture and deep sea fisheries-- all of which make up the watersheds and larger land division, the ahupua‘a and moku, have a big

role to play in helping Hawai'i adapt to climate impacts.

Soils and the supported food system are foundational to an ahupua'a-moku approach, and underpin any climate readiness in all lands and waters. Both are discussed briefly below.

Soil health is intricately linked to climate readiness

Managing lands for soil health can protect waterways and nearshore reef ecosystems in the face of other stressors such as increased ocean temperatures and acidification. Climate-smart land management practices that focus on building soil health, combined with stable land tenure, can provide ecological and economic resilience for agricultural communities throughout the islands and increase food system resilience. The U.S. Climate Alliance's Hawai'i Natural and Working Lands Research Team collaborates with stakeholders, resource managers, and local communities to support climate-smart land stewardship. Such stewardship includes crafting equitable, effective, and science-backed policies and programs that enable diverse groups to enact changes on the land that result in greenhouse gas (GHG) sequestration and the protection of natural resources while meeting local food production goals, biodiversity, watershed protection, and social and cultural values.

The current food system produces greenhouse gas emissions and affects public health

Globally, the food system generates an estimated 25-30% of total GHG emissions[50] [51] [52] [53] [54] and is a key social determinant of public health, with low-quality diets being a significant factor in the substantial rise of diet-related obesity and non-communicable diseases globally.[55] [56] [57] Dietary patterns, along with how agri-food systems are structured and managed, will have an overwhelming influence on the ability of global society to sustain critical ecosystems services, mitigate and adapt to climate change, and ensure food security, human health and well-being into the future.[58] [59] [60] [61] [62] [63] [64] [65]

Figure 5. Locally-produced agriculture is a vital part of our economy. Combining cultural wisdom with new scientific methods, carbon smart farmers can reduce carbon emissions and improve crop yields through utilizing cover crops, reducing tillage, agroforestry and other carbon smart practices. Here, loʻi (wetland taro farming) demonstrates the role cultural practices play in addressing food and climate resiliency. (Courtesy of Hawaiʻi Visitors and Convention Bureau Image Library)

Hawaiʻi's food system—dependent, vulnerable, and undiversified

With a residential population of over 1.4 million and 10 million annual visitors (pre-COVID-19), Hawaiʻi has one of the most food import-dependent populations in the world. Importing over 90% of its food and fertilizer, and over 73% of its energy, the Hawaiian Islands are uniquely vulnerable to statewide and community food insecurity in the face of anthropogenic climate change, fuel price fluctuations and other economic or natural disturbances.[66] [67] [68] [69] [70] In addition, the system of shipping food into Hawaiʻi has few functional redundancies built in.[71] [72] Simultaneously, the post-plantation agricultural economy of Hawaiʻi remains largely oriented toward external markets, with a diversified agriculture sector and regional food economy limited by a range of social, economic and political obstacles.[73] [74] [75] [76] With 41% of Hawaiʻi's agricultural lands currently unfarmed, [77] there is a huge opportunity to lower the state's food importation rates while mitigating climate change and protecting native ecosystems and cultural/traditional practices.

Climate change will impact food security globally and in Hawaiʻi

Climate impacts to U.S. and global agriculture, fisheries, and food system infrastructure have steadily increased over the last 10 years and are projected to increase in severity over this century.[78] [79] Such impacts on crop yields, food processing, storage,

transportation, and related infrastructure could significantly diminish the security of the U.S. and global food supply, drive food price spikes and negatively impact the availability of high-quality foods, especially to low-income and vulnerable communities.[80] [81] [82] [83] [84] [85] [86] [87] Further, it is understood that this warming may persist for millennia and result in severe economic and humanitarian crises by 2040.[88] Even with significant and coordinated efforts to limit global GHG emissions, all regions, including Hawai'i, must prepare for more frequent and severe climate-induced shocks, disruption of critical supply chains and fisheries, increased food insecurity, and the catastrophic loss of life, livelihoods, property and infrastructure.[89] [90] [91] [92] [93] [94] [95] [96]

Effects on vulnerable communities in Hawai'i

High rates of food insecurity and diet-related health disparities have long impacted the Native Hawaiian and low-income communities.[97] [98] [99] Legal cases over water rights and access to quality farmland and housing remain unresolved for many communities.[100] [101] [102] [103] [104] [105] This situation raises questions as to the sustainability, resiliency and equity of Hawai'i's existing food system and its ability to meet the long-term economic, ecological, cultural, public health and food security needs of its population. Under stochastic biophysical and/or social-economic shocks, it underscores the need to become more resilient. [106] [107] [108] [109]

To better adapt and mitigate within a rapidly changing climate, Hawai'i will need to make a range of systemic changes. Its forests, food system, agricultural lands, rangelands, and nearshore waters can all play a role in providing that resilience to climate change.

A. The role of native forests in resilience

Native forests and agroforests make Hawai'i more resilient and healthier; they filter air pollution, capture water and slow the intensity of rainfall which reduces erosion and run-off, and reduce heat islands in cities through shade which provides relief from oppressive temperatures and a reduced need for air conditioning; and more. The potential of these systems is important to consider in making Hawai'i climate ready, as they help build resilience in landscapes by enhancing a suite of ecosystem services.

Globally, degradation and loss of native forests is destabilizing natural systems on a scale unseen in human history. Hawai'i echoes this trend as half of its forests have already been lost.[110] In 2016, Hawai'i's forested

areas were the primary carbon sink in the state contributing the majority of the 6.51 MMT CO2 sequestered.[111] Healthy native forests are essential to stabilizing soil organic carbon which accounts for over half of the carbon stored in Hawai'i's terrestrial ecosystems (approximately 158.9 Tg C of the total 232.9 Tg C where one Tg = 1 billion kilograms).[112]

Protecting forest watersheds is the most cost effective and efficient way to replenish our aquifers and reduce impacts from climate change by absorbing GHGs and reducing flooding, erosion, and siltation of reefs and fisheries. Additionally, forests sustain irreplaceable cultural and natural values and facilitate social connections and cultural connection to place. Forests and agroforests are an essential part of the solution to tackle climate change and biodiversity collapse.[113] Healthy forests and agroforests provide jobs and sustainable livelihoods through forest products, conservation, and restoration.

B. The role of agricultural lands in resilience

Sustainably-managed agricultural systems can play a critical role in enhancing local food supplies, increasing resilience and adaptive capacity to climate change, and protecting Hawai'i's coral reefs ecosystems.[114] [115] [116] [117] [118] [119] There are a number of models of sustainable food systems in Hawai'i, including approaches that incorporate Indigenous management strategies, that can help to build resilience, and support biodiversity and ecosystem services.[120] [121] Recent research suggests that Indigenous agroecosystems (including agroforestry, *lo'i* systems, and dryland agriculture) supported large populations of Native Hawaiians pre-European contact, and that many of the areas that these systems likely occupied are still viable today. By contrast, Hawai'i's legacy of plantation agriculture has left many of the most highly productive soils in the state in a degraded condition. There are, however, many producers interested in reversing this trend.[122] Climate-smart agricultural management choices support soil health over time which provides beneficial outcomes for air and water quality, human health, groundwater recharge, nearshore ecosystem resilience, increased drought tolerance of crops and plants, reduced impacts of flooding, increased crop and livestock productivity, and overall ecosystem resilience.

C. The role of nearshore lands and waters in resilience

Hawai‘i’s ocean waters and reefs are local and international treasures, providing cultural, economic, and recreational opportunities to residents and visitors.[123] Not only do they drive both our local and tourism economies, generating over $360 million each year,[124] but play a significant role in climate readiness through healthy reef systems that provide coastal flood protection valued at $835 million annually.[125]

Coastal estuaries and food production practices can mitigate storm impacts[126]

Estuarine ecosystems provide a “spongy” coastline that is more resilient to climate impacts than a hardened one. Research done in Hawai‘i and other Pacific Islands shows that coastal vegetation can mitigate the impacts of storm surges and tsunamis to varying degrees, and serve as a green buffer against these events.[127] In addition to natural wetlands and estuaries, traditional food production practices such as loko i‘a (Hawaiian fishponds) and lo‘i kalo (wetland or flooded field taro systems) provide important ecosystem services (e.g. sediment retention, flood mitigation, wave attenuation, stormwater filtering), and function as important nature-based solutions.[128]

Figure 6. Native plants like Naupaka, Beach Morning Glory, and Aki Aki help minimize erosion along our shorelines. Dune restoration at Bellows Air Force Station (left) and Waihe‘e Refuge (above), shown here, are examples of living shorelines. These help mitigate erosion, and provide co-benefits such as habitat for native species, sediment filtration, and protection against storm and high wave events. (Courtesy of Anukriti Hittle)

III. Nature-based Solutions: "Green-blue" Efforts in Hawai'i Illustrate Climate Readiness

While there is no one particular definition of nature-based solutions (NBS), the general concept encompasses the use of "green-blue" strategies to address climate impacts. The International Union for the Conservation of Nature defines NBS as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."[129] The Nature Conservancy describes NBS as "project solutions that are motivated and supported by nature and that may also offer environmental, economic, and social benefits, while increasing resilience. Nature-based solutions include both green and natural infrastructure." The Environmental and Energy Study Institute defines NBS as "Restoring and/or emulating nature in order to increase human, ecosystem, and infrastructure resilience to climate impacts."[130]

Nature-based solutions, when rooted in place-based value and knowledge, can provide climate resilient solutions, and are often less expensive and more effective than their conventional "gray" counterparts alone[131] [132]. These solutions often also provide a greater array of co-benefits than "gray" infrastructure alone. For instance, protecting native forests or restoring culturally-valuable agroforests as part of a climate adaptation strategy, can simultaneously provide erosion control, biodiversity, and cultural benefits. The nature-based examples below illustrate local, state and regional efforts in Hawai'i to adapt to climate change.

Nature-based solutions, when rooted in place-based value and knowledge, can provide climate resilient solutions, and are often less expensive and more effective than their conventional "gray" counterparts alone. These solutions often also provide a greater array of co-benefits than "gray" infrastructure alone.

Figure 7. Our mauka natural and working lands include forests and a variety of agricultural and ranching lands. The management of these lands plays an important role in reaching our net negative carbon goal, and sustainable management of these lands provides a suite of benefits beyond carbon. (Courtesy of Leah Laramee, DLNR-DOFAW)

A. Examples: Mauka Lands

1. Noteworthy are two state-implemented forest carbon projects, that not only can reduce GHG emissions, but also provide cultural and resilience benefits through forest conservation and restoration, maximization of freshwater capture and storage, reduction of erosion, and creation of green jobs.[133] The Puʻu Mali Forest Carbon Project on the slopes of Mauna Kea (Hawaiʻi Island) is focused on restoring an area that was once prime forest habitat but was converted into agricultural land. This area will provide habitat for native species (e.g., palila, *Loxioides bailleui*) and is estimated to withdraw 98,000 metric tons of carbon from the atmosphere.[134] The Kahikinui/Nakula Forest Carbon Project on the slopes of Haleakalā (Maui) is an alien grassland that was once a native forest of koa and ʻōhiʻa lehua. The restoration of this area will withdraw an estimated 94,000 metric tons of carbon, provide habitat for many endangered species, and mitigate wildfire threats.[135]

2. Range lands occupy over 20% of Hawaiʻi's land area and are a critical component of sustainable land management and climate adaption. Well-managed rangelands can provide a range of ecosystem services including watershed protection, carbon sequestration, open space preservation, wildfire mitigation, habitat preservation, noxious weed control, and cultural values. Ranches across Hawaiʻi work both to maintain and manage

healthy grassland systems as well as to protect and restore native ecosystems. In managing healthy rangelands, ranchers provide a suite of services that benefit native ecosystems and broader society, including controlling fires and invasive species. Haleakalā Ranch, for example, has implemented multiple conservation programs, staying true to its core value of land stewardship. Waikamoi Preserve is a partnership between Haleakalā Ranch and The Nature Conservancy where the Ranch granted a perpetual conservation easement to TNC to manage 5,230 acres of fragile watershed lands.[136] The ranch also focuses on sustainable rangeland management, implementing activities including wildfire and invasive species control, vegetation cover maintenance, and koa forestry. The Koa Restoration Program and Nene Safe Harbor program are two more noteworthy conservation programs occurring at Haleakalā Ranch.[137] Kualoa Ranch is similarly dedicated to mālama' āina, and does so through various initiatives, including the restoration and upkeep of an 800 year old Moli'i fishpond, implementing fencing to protect rare and endangered species, outplanting of native species, restoring lo'i, and clearing streams.[138]

3. Strengthening community capacity for stewardship is crucial to resource management. The Stewardship Mapping and Assessment Project (STEW-MAP) highlights sites on Hawai'i Island and O'ahu in an online geospatial database that aims to make visible and elevate community-based and civic efforts to care for our natural-cultural resources. By highlighting gaps and concentrations of care for regions, the platform becomes a resource for community groups and partner agencies to effectively communicate and collaborate with each other, to identify opportunities to support community-based efforts and to enhance the capacity of stewards.[139]

> **Well-managed rangelands can provide a range of ecosystem services including watershed protection, carbon sequestration, open space preservation, wildfire mitigation, habitat preservation, noxious weed control, and cultural values.**

B. Examples: Ahupuaʻa

1. Several statewide projects address soil health, watersheds, and fishponds, illustrating the interconnectedness of the ahupuaʻa.
- A project to develop a decision-support tool that will aid farmers in understanding the linkages between management practices that aggrade, degrade, or maintain soil is underway at the University of Hawaiʻi.[140] This tool will support healthy and resilient soils, landscapes, and communities.

- Another soil-focused project is producer-driven and aims to identify barriers and challenges farmers face in adopting soil health management systems and the social, economic, and environmental impacts of these management systems. Other research has looked at the potential of Indigenous agricultural food production under climate change in Hawaiʻi and determined that both loʻi and colluvial agroforestry systems could be resilient in a wide range of future climate shifts.[141]

- The Mōhala I Ka Wai project[142], supported by the Honolulu Board of Water Supply and many more partners, is focused on restoring Mākaha Valley (Oʻahu) areas through *loʻi* restoration with hopes of restoring the valley and stream flow.

- Currently, 63% of seafood consumed in Hawaiʻi is imported. By increasing aquaculture in Hawaiʻi, we can reduce our reliance on imported foods, provide jobs, and minimize the strain on our marine resources. The *Statewide Programmatic General Permit and Programmatic Agreement for the Restoration, Repair, Maintenance and Reconstruction of Traditional Hawaiian Fishpond Systems Across Hawaiʻi* is a program that aims to streamline the permitting process for the restoration, repair, maintenance and reconstruction of loko iʻa.[143] This program will stimulate the restoration of fishponds statewide, and result in valuable cultural and ecological services.

2. The crucial role of watersheds and watershed partnerships in resilience is codified in the State's commitment to protecting 30% of its highest priority watersheds by 2030. The 30x30 Watershed Forests Plan outlines strategies to meet this goal: increasing access to nature, controlling nonnative ungulates and plants, preventing wildfires, combatting forest diseases and pests, planting native trees, educating residents and visitors, and supporting watershed partnerships.[144] Through the 30x30 initiative, Hawaiʻi has already planted over

120,000 native trees, provided 80+ jobs per year, and protected 210 endangered plants and animals.[145]

3. Several forest and watershed restoration examples from Kauaʻi highlight the connection between traditional knowledge, ecosystem benefits and resilience:

- Research conducted in Limahuli Valley, Hāʻena, Kauaʻi, outlined a method to assess restoration strategies through cultural outcomes, ecological outcomes, and hydrological outcomes.[146] The research identified a hybrid restoration strategy, which included native, Polynesian-introduced and modern-introduced species as the most resilient strategy, while also supporting the highest cultural values and native species.

- The connections between water quality, wildlife refugia and traditional taro farming are highlighted in the community and kūpuna feedback that was incorporated into the U.S. Fish and Wildlife Service's (USFWS) Comprehensive Conservation Plan at Hanalei National Wildlife Refuge. "Talk story" sessions led the USFWS to articulate goals to "focus additional effort on water security and quality for the wetland refuges, especially in regards to taro farming on the refuge..." and to "focus on improving the refuge's coordination/partnership with the refuge taro farmers of Hanalei valley."[147] [148]

- Located in one of the most biodiverse valleys in the Islands, the National Tropical Botanical Gardens in Hanalei utilizes ancestral resource management practices like loʻi kalo to "restore health, function, and resilience to the valley". At the Limahuli Garden and Preserve, "a puʻuhonua (place of refuge) for an ecological system that honors the connection between nature and humanity, where Indigenous traditions live in the 21st Century," this effort provides visitors with educational opportunities through tours or hands on work and locals a chance to connect to the culturally important system of loʻi kalo, all while supporting the biodiverse ecosystem that surrounds it.[149] [150] More such efforts, based in local and traditional practices, will help with resilience and climate readiness.

Figure 8. Located in one of the most biodiverse valleys in the Islands, Limahuli Garden and Preserve in Hanalei demonstrates the connections between traditional knowledge, ecosystem benefits and resilience. (courtesy of Steven Gaertner)

C. Examples: Makai Lands and Nearshore Waters

1. Demonstrating the interconnectedness of culture, food resiliency, and sustainable agricultural practices, partners Kakoʻo ʻŌiwi, Paepae o Heʻeia, and the Heʻeia National Estuarine Research Reserve utilize traditional management practices including agroforestry, loʻi kalo (wetland taro), and loko iʻa (marine fish ponds) while increasing biodiversity and ecosystem services.[151]

2. Hawaiʻi Sea Grant has conducted multiple projects that address SLR issues and climate-related vulnerabilities. For example, three at-risk sites with high erosion rates on Oʻahu- Sunset Beach, Waikīkī, and Pearl Harbor- were analyzed as to the efficiency of living shoreline (coastal sand dunes, vegetation, and coral reefs) and green infrastructure (widening of floodways adjacent to rivers, temporary water detention, and stream/river bank elevation and stabilization) strategies to protect coastal communities, buildings and infrastructure.[152] Such projects help build climate readiness in Hawaiʻi.

3. Non-profit partners help manage coastal lands, and to varying degrees, use nature-based approaches. One such example is the Hawaiian Island Land Trust (HILT) which conserves "lands that enable Hawaiʻi's long-term well-being, lands with scenic views, agricultural resources, wildlife

habitats, water resource areas, cultural and historical values, and outdoor recreation opportunities."[153] Statewide guidance and coordination of approaches would provide even more effective results in making Hawai'i climate ready.

Figure 9. Hawai'i currently has multiple initiatives in place to ensure the protection of its coastal habitats and coral reefs. From the Coral Bleaching Recovery Plan that includes comprehensive pathways to meet the state's goal of promoting coral reef recovery, to the Industry Coral Pledge which incentivizes companies involved in marine tourism to commit to coral-safe practices, these strategies provide necessary mauka-makai connections for resilience. (Courtesy of Getty Images)

4. The restoration of loko i'a in Hawai'i, like in the culturally important Kīholo Preserve area on Hawai'i Island, provides cultural, spiritual and economic benefits, increases the state's food production rate, provides habitat to many native fish species and seabirds, and has been correlated with increasing coral reef resilience. The coral reef adjacent to the Kīholo fishpond was found to be "the most resilient to climate change impacts of twenty reefs studied in West Hawai'i."[154]

5. The DLNR Office of Conservation and Coastal Lands is updating its Small Scale Beach Restoration Permitting Program to facilitate permitting of beach and dune environmental restoration projects as a nature-based alternative to shoreline hardening, such as seawalls and revetments, which have been shown to lead to beach loss on eroding coasts. [155]

6. Land-based source pollutants are a huge threat to coral reef ecosystems. Research in West Maui developed a decision-support tool to determine the optimum management strategies for minimizing sediment delivery to coral reefs while also minimizing costs.[156] Strategies included watershed restoration, ungulate fencing, invasive species control, green infrastructure and working with farmers

and ranchers to reduce nutrient input.

7. Hawai‘i currently has multiple initiatives in place to ensure the protection of its coastal habitats and coral reefs. The Coral Bleaching Recovery Plan was implemented following the 2014-2015 coral bleaching event and includes comprehensive pathways to meet the state's goal of promoting coral reef recovery,[157] while the Industry Coral Pledge incentivizes companies involved in marine tourism to commit to coral-safe practices,[158] and the Coral Restoration Nursery is using innovative strategies to repopulate and restore our reefs.[159]

8. The Holomua Marine 30x30 Roadmap lays out the state's commitment to effectively managing 30% of Hawai‘i's nearshore waters by 2030.[160] As its name implies, the Holomua plan includes a range of adaptive management techniques which aim to work "together with community members, local, state and federal government agencies, and other stakeholders we hope to usher in a new era of participatory and place-based adaptive management that is scientifically and culturally-informed."[161] There are four pillars to support effective management: place-based planning, pono practices, monitoring, and protection and restoration. All of these will require further articulation about how we can collaborate from mauka to makai to make Hawai‘i truly climate ready.

D. Broader Alliances for Climate Readiness

Through effective regional and global partnerships, the state can plug into the larger efforts that address systemic changes on regional and global scales. These efforts take their cues from the place-based work in Hawai‘i, and in turn, are strengthened by the larger efforts into which they feed. For example:

- Holomua Marine 30x30 Initiative and 30x30 Watershed Forests Target are part of a larger Sustainable Hawai‘i Initiative, announced by Governor Ige at the 2016 IUCN World Conservation Congress, which includes goals for local food production, biosecurity, watershed protection, marine management, and renewable energy. Together, these initiatives will benefit our mauka land, coral reefs and coastal habitats, and address resiliency.[162]

Figure 10. Hawai'i is actively engaged in partnerships that address systemic changes on regional and global scales. These efforts take their cues from the place-based work in Hawai'i, and in turn, are strengthened by the larger efforts into which they feed. (Courtesy of Shellie Habel, DLNR-OCCL)

- Hawai'i's partnership with the International Alliance to Combat Ocean Acidification has enabled us to join a global network of governments that are working together to decrease ocean acidification.[163] The State of Hawai'i is developing an Ocean Acidification Action Plan to address specific actions that can be taken in Hawai'i's unique environment.

- Hawai'i is an active member of the U.S. Climate Alliance which released a "Natural and Working Lands Challenge" that "invites all national and subnational jurisdictions, tribes, businesses and other actors to make commitments to reduce GHG emissions and protect and enhance carbon sequestration across all natural and working lands."[164]

- As part of the global 1 trillion tree initiative which aims to grow 1 trillion trees by 2030, Hawai'i has pledged to protect or plant 10 Million trees a year for a total of 100 million trees over the next decade.

- At the 2019 United Nations Framework Convention on Climate Change summit, Hawai'i signed a bi-coastal sun-national agreement that recognizes that states must decrease greenhouse gas emissions and ocean-specific emissions, increase ocean-related mitigation, facilitate the development of clean and renewable energy, increase the resilience of coastal ecosystems, communities, and economies, and reduce stressors on the ocean.

IV. Resilience Framework Components for Hawai‘i

1. Defining resilience

To achieve a Climate Ready Hawai‘i, it is important to first have a shared understanding of what it means to be resilient to climate change. This provides a common understanding of what success would look like, and provides the consistency needed to achieve common goals. While resilience has not been defined statewide, the City and County of Honolulu's *O‘ahu Resilience Strategy* defines resilience as "the ability to survive, adapt, and thrive regardless of what shocks or stresses come our way."[165] The county states that resilience is built at the intersection of the environment and the economy and confirms that institutions must recognize the importance of all city systems- health and well-being, economy and society, infrastructure and environment, and leadership and strategy- when building resilience.

The U.S. Climate Alliance's *New Governors' Resilience Playbook* reminds us that resilience is defined as: "the capacity to recover quickly from difficulties; toughness."[166] The *Playbook* adds that "[r]esilience is the ability of people, communities and institutions to

Figure 11. To better adapt and mitigate within a rapidly changing climate, Hawai‘i will need to make a range of systemic changes—and its forests, food system, agricultural lands, rangelands, and nearshore waters can all play a role in providing that resilience to climate change. Here, these flooded taro fields in Hanalei illustrate the timelessness of this ancient Hawaiian practice, and the importance of the reciprocal relationship between the land and its people. (Courtesy of Moonjazz, Flickr)

prepare for, withstand, and bounce back more rapidly from acute shocks and chronic stresses." The Alliance further defines resilience as the ability for our states and communities to prepare for, endure, and overcome environmental and economic stressors and disturbances induced by climate change.

At the state level, California defines resilience as "strong infrastructure, communities and natural systems that can withstand increasingly volatile conditions."[167] Delaware defines resilience as "the ability to adapt to changing conditions and rapidly recover from disruptions due to emergencies." Massachusetts, in its State Hazard Mitigation and Climate Action Plan characterizes resilience as the ability to "position the Commonwealth to effectively reduce the risks associated with natural hazards and the effects of climate change."[168] The Alliance further defines resilience as the ability for our states and communities to prepare for, endure, and overcome environmental and economic stressors and disturbances induced by climate change.[169]

Defining food system resilience & equity

Food system resilience is defined as the capacity over time of a food system to provide sufficient, appropriate and accessible food to all in the face of various biophysical, social, or economic disturbances.[170] [171] [172] Food system equity is defined as a goal, outcome or condition of the food system where the benefits and risks of how food is grown and processed, transported, distributed, and consumed are shared equitably by society.[173] [174] [175] [176] To achieve food system resilience and equity, the following food system resilience attributes must be developed and sustained through time: system awareness, system diversity, system integration, system self-regulation, adaptive capacity, and inclusivity & equity.[177] [178] See Box 1 for details.

Box 1: Food System Resilience Attributes.

- **System awareness:** The community and government have knowledge of food system assets, liabilities, and vulnerabilities. This includes situational awareness, which allows for assessing new information and adjusting to shocks and stressors in real time.
- **System diversity:** The system has various sources of capacity enabling it to function when some elements are stressed or challenged; the system contains redundant or complementary elements.
- **System integration:** The larger system has coordination of function across all internal systems, allowing disparate ideas and elements to coalesce into collaborative solutions through information sharing and transparent communication.
- **System self-regulation:** The food system can regulate itself without extreme malfunction. Cascading disruptions do not cause complete failure; the system can fail safely.
- **System adaptive capacity:** The food system is flexible and can adapt to changing circumstances, modifying behaviors, and adapting existing resources to new purposes.
- **System inclusivity & equity:** An inclusive food system is one that emphasizes broad consultation and engagement of communities, including the most vulnerable and historically marginalized groups. A more equitable food system is realized when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and cultural preferences for an active and healthy life.

Source: Biehl (2017), and Harris and Spiegel (2019).[179] [180]

2. General principles for resilience in Hawai‘i

So, what would Hawai‘i need to do to bounce back from shocks, and to deal with ongoing climate stressors? Hawai‘i cannot be resilient to climate change without addressing all systems—natural, economic, community and cultural. Such readiness includes carbon sequestration and its co-benefits, addressing ocean acidification to strengthen coral reefs, and sea level rise and together drive successful adaptation to climate change. In order to be climate ready, nature-based solutions rooted in place are key to reducing risk, improving water and food security, and creating a Hawai‘i that will not only be resilient but indeed, one that flourishes. These general principles for climate readiness in Hawai‘i are described below.

The need for Hawai‘i relevant nature-based solutions

NBS, as discussed earlier, provide a robust framework for resilience where the co-benefits of carbon sequestration, ecosystem benefits and economic enhancement come together. Through planning with strong community and Indigenous participation, NBS can also have strong local community and cultural benefits.[181] The examples presented earlier in this document highlight several Hawai‘i-relevant solutions that could be upscaled to prepare for climate readiness.

> **Hawai‘i cannot be resilient to climate change without addressing all systems—natural, economic, community and cultural.**

The need for biocultural approaches in Hawai‘i

Biocultural approaches to resource management and stewardship can be effective in addressing sustainability and climate change.[182] In Hawai‘i, Indigenous resource management systems supported a large human population without over-exploiting the island’s resources.[183] The knowledge and practice of how to adapt to and recover from the variable climate and natural disasters of Hawai‘i are inherent to these Indigenous resource management systems.[184]

Figure 12. The ʻōhiʻa lehua is an indigenous tree that is deeply engrained in Hawaiʻi's culture. It is also considered the most ecologically important native tree in Hawaiʻi. This durable species is one of the first to recolonize an area after lava flow and makes up over half of the native tree population in the state, providing habitat to many native species and protecting watersheds. Climate change poses a great threat to this cuturally significant species, and several efforts are underway to restore and protect it. (Courtesy of Kerri Rouse, DLNR-DOFAW, Oʻahu NEPM)

Such approaches recognize and draw upon the "critical feedbacks between ecological and human well-being, whereby stewardship of place is inseparable from stewardship of people, their cultural practices, and their values."[185] [186] [187] Biocultural approaches can help provide an understanding of resilience.[188] Biocultural approaches allow for the synthesis of multiple ways of knowing, which "can foster greater human adaptive capacity and ecological resilience".[189] In Hawaiʻi, biocultural approaches are strongly informed by Indigenous Hawaiian perspectives, knowledge, and expereinces, as well as diverse knowledge-practice-belief systems representative of Hawaiʻi's diverse communities. Biocultural restoration and biocultural approaches to policy and other resource management plans have been studied extensively in Hawaiʻi and have shown to be impactful with positive results.[190] Going forward, more integration of such approaches into plans and strategies for Hawaiʻi are essential to climate readiness.

The need for decision support tools

Decision support tools (DSTs) are critical to our community of resource management stewards to help in achieving resiliency outcomes. Unfortunately, stewards, resource management agencies, and decision and policy makers often lack access to data resources and technology-based tools needed to assess trade-offs in designing efficient and cost-effective strategies. Geospatially-driven DSTs, for example, have translated scientific papers into maps that stewards, resource managers and decision and policy makers could then use to identify the most effective conservation goals to meet the needs of diverse stakeholders.

A Climate Ready Hawai‘i will need to rely on the generation of tools informed by the best available data. A DST approach can facilitate efforts to analyze multiple datasets and prioritize one or more socio-ecological benefits, while engaging important and often limiting logistical and operational considerations. Overall, a DST based approach to forging a Climate Ready Hawai‘i can provide a quantitative mauka-makai and ahupua‘a-moku framework for identifying, modeling and understanding how resource stewardship responses to climate change best support Hawai‘i’s efforts to sustain, restore, and enhance the resilience and resistance of our ridge to reef ecosystems.

3. Resilience Metrics

To measure Hawai‘i’s progress towards becoming climate ready, metrics of readiness need to be identified and tracked. While such metrics have not yet been identified for the state, efforts are underway to develop and incorporate them into trackers through the Aloha+ Challenge Dashboard, and the Resilience Working Group of the U.S. Climate Alliance.[191] [192]

In the *O’ahu Resilience Strategy*, the City and County identified 44 actions for the county to take to achieve its goals of ensuring an affordable future for O‘ahu, fostering resilience in the face of natural disasters, tackling climate change by reducing emissions and adapting to impacts, and leveraging the strength and leadership of local communities.[193] Action-specific performance metrics have also been identified, which allows the county to track its progress in accomplishing these goals. For example, one action described in the *O‘ahu Resilience Strategy* is utilizing seawater air conditioning systems that bring deep seawater to a central cooling station on shore to replace energy-taxing conventional air-conditioner systems. The county will measure its success in implementation by tracking the “percent of eligible municipal buildings connected to district cooling system”, and will determine the effectiveness of the action by tracking the

"energy reduction/greenhouse gas emissions reduction by all participants on system."

California's guidebook for state agencies underscores the importance of resilience metrics, and provides the following overall context for them: "To understand the performance of plans and projects, it is important to develop a set of metrics linked to the management objectives of a plan or investment under current and changing climate conditions.....State entities should maintain a list of specific actions taken and track their effect on resilience, such as wetlands conserved to buffer sea level rise".[194] In other jurisdictions such as Boston and Colorado, Climate Ready initiatives have identified sector-specific strategies and recommendations.[195] Both jurisdictions identified strategies targeted at improving the resiliency/adaptation and mitigation potential in areas such as public health and community resiliency, coastal protection, transportation and infrastructure, agriculture, water resources, and native ecosystems.[196] Boston additionally offers the public a tool to track the state's progress towards implementation.[197] Maine has also identified various pathways the state must follow to reach resilience and has made "Data, Monitoring, and Assessment" a focus of its plan.[198]

Figure 13. A truly resilient Hawai'i must employ nature-based solutions. When rooted in place-based value and knowledge, these solutions can be climate resilient, and are often less expensive and more effective than their conventional "gray" counterparts alone. Here, sandbags are used in a temporary attempt to protect property, and instead contribute to beach erosion. A living shoreline has shown to be more effective in protecting our beaches, and making a resilient coast. (Courtesy of Shellie Habel, DLNR-OCCL)

Indicators relevant to Hawai'i

This Working Paper acknowledges that there is a need for the Commission to embrace, support, and where appropriate, coordinate a statewide conversation of how Hawai'i-relevant indicators can be used for climate readiness. Here, we consider the use of a biocultural approach for Hawai'i, we briefly summarize three main resilience categories: ecosystem, social/cultural, and food. These are not, by any means, the full range of indicators, nor even approaches for climate readiness in Hawai'i. Ongoing community-based efforts such as 'Āina Aloha Economic Futures have been engaging in discussion and action to bring economic (and so, climate) resilience to life.[199]

A. Ecosystem resilience indicators

It is worth emphasizing that the authors do not believe that human systems are separate from natural ones, and in fact, are part of the same system, as described in the discussion on biocultural approaches above. However, for the purposes of this paper, ecosystems are discussed separately from human systems.

Studying ecosystem examples from other jurisdictions, relevant metrics may include the following:

- Acres of NWL using climate-smart practices to reduce carbon emissions
- Coastal vegetation conserved/restored to decrease coastal erosion
- Increase in well-managed rangelands to enhance ecosystem services and cultural values
- Decrease in food importation/ increase in local food production and increase in use of traditional agriculture methods
- Increase in biodiversity, conservation of traditionally important lands/forests- increased connection to place
- Marine indicators of reef health, such as biodiversity, fish diversity, benthic cover
- Terrestrial indicators of soil health, including soil carbon, microbial diversity, and nutrient availability
- Protected forests

B. Human health and well-being resilience indicators

As the COVID-19 pandemic has shown, adapting to climate change is going to require well-organized, connected communities and institutions that can make informed, fair, and effective decisions. Hawai‘i has been working on, and hopes to continue to use, place-based perspectives to inform policy and resource management. A statewide definition of resilience must include human health and well-being indicators, which would contain socio-cultural components.

When choosing social indicators of resilience in Hawai‘i, where its people are so intrinsically tied to the land, it is essential to include cultural ecosystem services (CES), which are defined as “the non-material benefits realized through human-environmental interactions”.[200] CES allow decision-makers to better understand how their strategies or policies may affect the human-environmental interface. Researchers collaborated with Native Hawaiian and kama‘āina communities to create a CES framework for Hawai‘i. The CES framework categories can be used as a starting point, and adapted to place-based contexts to help analyze the effect that adaptation and mitigation strategies have on local communities.[201]

Using a biocultural approach, researchers have also identified social indicators to assess progress on issues like food security, quality education, access to freshwater, sustainable tourism, and protection of marine resources.[202] The indicators most applicable to measure social resilience to climate change in Hawai‘i are collecting data on the “prevalence of food insecurity in the population, the proportion of bodies of water with good water quality, and coverage of protected areas in relation to marine areas.” NWL, for example, are critical spaces of social connections, networks and local knowledge, which are indicators of social resilience to climate change.

> **A statewide definition of resilience must include human health and well-being indicators, which would contain socio-cultural components... to assess progress on issues like food security, quality education, access to freshwater, sustainable tourism, and protection of marine resources.**

C. Food system resilience indicators

In contrast to a thriving local food system in Hawai‘i prior to European contact, Hawai‘i produces just 13% of its food, though subsistence food has been poorly quantified.[203] Any disruption to the shipping lines and food import, storage and distribution systems from climate shocks and stressors puts Hawai‘i at great risk. It is vital that a climate ready Hawai‘i contain strategies to ensure that our food systems can bounce back from unexpected climate-related events.[204] [205] Researchers, state officials, and community leaders believe there is a critical need to bridge multiple agencies and initiatives to draft a statewide strategy for achieving food system resilience and equity.

Food production and distribution systems are dynamic systems that incorporate the environment, ecosystems, and social institutions. The following characteristics have been identified as indicators of a resilient food system: (1) energy and nutrient sovereignty via the use of domestic, renewable energy sources, such as biogas, the recycling of nutrients, and energy efficiency; (2) transparency, dialogue, and equity in the food chain; and (3) innovativeness and learning, utilizing technology, developing expertise, and research based know-how.[206] [207]

Increasing Hawai‘i’s food security through sustainable, traditional, or resilient agricultural systems will contribute to the state’s climate readiness by stimulating the economy, decreasing our reliance on imports, and increasing cultural and spiritual values for our communities.

V. Next Steps to Readiness

This document demonstrates that there is significant work already underway in Hawai‘i, and that this work has potential for scalability and replicability. From the discussion above, it follows that some next steps to a Climate Ready Hawai‘i are:

1. Measuring resilience and progress

A statewide process is needed to define resilience and measure progress towards it. Hawai‘i’s resilience goals, participation and engagement in such a process have yet to be identified, along with relevant indicators and metrics of resilience.

2. Operationalizing equity

Coordination across all government agencies and departments is needed to articulate how to operationalize equity in government processes and planning for a resilient Hawai‘i.

3. Developing a knowledge exchange

To further support the many impressive efforts being made at local and statewide levels, a Hawai‘i Climate Exchange (HICE) is proposed. HICE can provide a vehicle for coordination of climate readiness information across multiple jurisdictions and partners.

Because of its multi-jurisdictional structure, the Hawai‘i Climate Commission is an ideal entity to help coordinate these efforts and conversations, and further integrate resilience-building work on NWL, coastal lands, nearshore waters and the deep ocean. Such coordination will be crucial to making Hawai‘i climate ready for what is undoubtedly coming and, indeed, already here.

PAU

Note on the use of Hawaiian language and words

Hawaiian is the Native language of Hawai‘i and, per the Hawai‘i State Constitution, an official language of the State of Hawai‘i. As such, Hawaiian language is used throughout the document. Per University of Hawai‘i’s *Style Guide 2013*, Hawaiian words are not italicized in this document.

Glossary of Hawaiian Terms

The following glossary provides English translations of Hawaiian words, from Pukui and Elbert (1986). Hawaiians today may use more contemporary meanings for some of the words; these words are translated to current meanings, marked with “(common),” and any other text is from Pukui and Elbert (1986).

ahupua‘a: Land division usually extending from the uplands to the sea, so called because the boundary was marked by a heap (ahu) of stones surmounted by an image of a pig (pua‘a), or because a pig or other tribute was laid on the altar as tax to the chief.

kūpuna: Grandparent, ancestor.

lo‘i kalo: wetland or flooded field taro systems (common).

loko i‘a: Hawaiian fishponds (common).

makai: Ocean-ward (common).

mālama ‘āina: To take care of the land (common).

mauka: Landward (common).

moku: District, island, islet, section.

pu‘uhonua: place of refuge.

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Endnotes

[1] Lenton, Timothy M. et al. "Climate Tipping Points — Too Risky To Bet Against". Nature, vol 575, no. 7784, 2019, pp. 592-595. Springer Science And Business Media LLC, doi:10.1038/d41586-019-03595-0.

[2] "Food Security And Food Production Systems". Ipcc.Ch, 2018, https://www.ipcc.ch/report/ar5/wg2/food-security-and-food-production-systems/.

[3] "Climate Change Portal". Climate.Hawaii.Gov, 2021, http://climate.hawaii.gov/. The Hawai'i Climate Change Mitigation and Adaptation Commission, created to support the U.S.'s commitments under the Paris Agreement, is generally tasked with identifying, coordinating and supporting climate change mitigation and adaptation strategies under HRS 225P-3.

[4] "Panel 2. Paddling Together To Accelerate Actions For Adaptation To Sea Level Rise". Climate.Hawaii.Gov, 2019, http://climate.hawaii.gov/wp-content/uploads/2019/02/Panel-2-Paddling-Together-FINAL-feb-13.pdf. Climate **Ready Hawai'i** was born of recommendations shared at the State's first annual climate conference held in January, 2019. An expert panel recommended that the State "consider adopting a community resilience building planning process to help Hawai'i's communities, counties and institutions of any scale to identify their top priorities based on climate change hazards cross-referenced to strengths and vulnerabilities relative to infrastructure, social and environmental characteristics."

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